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Proceedings of The Institute of Acoustics

Infrasound Project at the University Centre of Aalborg.

by Henrik Møller,
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This paper will contain three parts. First I will give an introduction concerning my point of view on the infrasound research and of our project related to that. Next I will give a description of an infrasound test chamber, which we have built, and at last I will shortly describe some experiments, that are going on right now. Unluckily I cannot tell you any results yet.

Introduction.

It is very well known, that infrasound has been one of the mysterious subjects within acoustics, and opinions have been very different. Some investigators have mentioned, that infrasound should be able to cause severe reactions from the human body and mind at as low levels as 70 to 80 dB. On the other hand, other investigators have been of the opinion, that infrasound should be rather harmless at levels up to 150 dB.

The research done at the very high levels of infrasound has mainly been carried out in relation to aerospace research programmes. The purpose has been to find out, whether the human being can withstand the high levels of infrasound, which occur for example at rocket take–offs. The exposure times have only been short, say two or three minutes. Although the results from these experiments do not show dangerous effects, one should be very careful using the results as evidence of the harmlessness of infrasound of longer duration even at much lower levels.

The reports of infrasound effects at low levels are mainly of the case–story type. The typical story tells us about a place, where people complain of dizziness, headache, nausea, loss of concentration or other things, and where the only unusual thing, experts can find, is some infrasound. From these case–stories it is, of course, almost impossible to prove, that the complaints really are caused by the infrasound.

Therefore laboratory experiments are needed, and a number of investigators have started these. However results are not very concordant, and no conclusive results are available. Some reports seem to indicate, that the infrasound problem has been exaggerated, but even if all experiments fail to show severe reactions caused by infrasound, there is still the problem of annoyance. As infrasound can be heard above a certain sound pressure level, people may judge it to be unpleasant, exactly as it is the case with sound in the audio range. In this respect the steep slope of the loudness curve and possible effects of audio frequency masking may be of importance.

As time goes by, occurrence of man made infrasound is still increasing, and I think, it is very important to clear up these problems and to establish well documented and well accepted limiting values for human exposure to infrasound.

On basis of these considerations, I feel, that the most important thing to do, is to try to verify some of the observations reported in the case–stories by laboratory experiments. This means, that we need a test chamber, where subjects can be exposed to infrasound at levels which are met in our everyday environment. The construction of our chamber began in 1975, and it was finished in november 1977.

The test chamber.

Figure 1 is a drawing of a part of the laboratory. In the corner the test chamber has been built of concrete. It has a volume of 16 cubic metre, and the largest dimension is 2.8 metre. The chamber is so large, that work can be carried out in it, and two or more persons can be under test at a time. The chosen dimensions also serve to minimize the psychological influence of the room. There are no tuning holes for making a resonator, because we want a flat frequency response for the whole system. In this way it is possible to reproduce a real environmental infrasound signal recorded on an FM tape recorder. The infrasound is generated by 16 large loudspeakers mounted in one wall of the chamber. In order not to let the infrasound escape from the system, the back side of the loudspeakers is covered by another room built of concrete, called the back volume.

The loudspeakers, which are used, have a diameter of 13 inches, and they are each able to move nearly one litre of air in one stroke. With sixteen loudspeakers, we are able to reach a peak sound pressure level of 128 dB. This should be sufficient for presenting most of the infrasound spectra, which are met in our everyday environment. The needed peak effect from the power amplifier is nearly 200 W. In order to achieve a smooth frequency response and a convenient total gain, an electronic filter has been applied at the input of the power amplifier. With 1 V at the input of this filter we get a sound pressure level of 120 dB, and the frequency response is flat up to about 30 Hz, see figure 2.

Figure 2 shows a lower limiting frequency, which has not yet been mentioned. It is due to air leakage through the walls. This is a very difficult problem to handle, and the fairly low 3 dB point of 0.06 Hz has only been obtained by covering all walls with some kind of a plastic layer.

One important thing in a room like this, is the purity of the sound. With loudspeakers as infrasound generator we do not have the high frequency components, which are often seen with hydraulic systems, and even the harmonic distortion is very low. Figure 3 shows a measurement of the harmonic distortion at a sound pressure level of 120 dB. Both the 2nd and 3rd harmonics are more than 40 dB below the fundamental. This should be sufficient even for determining hearing threshold levels.

For our experiments it is essential, that the stimulus is purely acoustical, which means, that the vibration levels should be sufficiently low. Figure 4 shows the vibration level at some of the surfaces of the room, when the sound pressure level is 120 dB. These are the curves a, b, c and d. e and f are the strongest requirements of the ISO standard 2631. The strongest requirements are those of "reduced comfort" for an exposure of 8 hour/day. We are much below these levels except for the door, which is shown as the curve g.

As we intend to make experiments lasting for several hours, some kind of a ventilating system is nessecary. A solution is chosen, where an airflow of 50 cubic metre/hour under pressure is blown through flow resistances in and out of the chamber. Of course, the flow resistances will act like air leakages, and thus increase the lower limiting frequency. Of this reason, the test chamber cannot be used below 0.5 Hz when the ventilating system is used.

Infrasound Project at the University Centre of Aalborg.

Experiments.

This last part of the paper will contain a short description of some experiments, that are going on right now. 16 young students are used as test persons. They all take part in the experiment four times, each time for 4 hours. One time is without any sound stimulus, one time they are exposed to traffic noise with an Leq of 70 dB, and two times the stimulus is an infrasound noise band at two different levels, see figure 5.

The subjects are sitting two at a time in the chamber. During the exposures the subjects work with duties, presented to them either on a small film viewer or on a cathode ray tube display terminal. Examples of the duties are reaction time measurements, addition duties, figure inspection tests and short time memory duties. Some of them are developed at the Technical University of Denmark, where they have been used for monitoring human performance under different conditions of air temperature, humidity of air and the like.

During the exposures some physiological signals are recorded. We measure the electrocardiogram, the respiration, the fingerpulse and the phonocardiogram. These signals are stored by means of two FM taperecorders, and a later analysis is needed. Every hour the arterial blood pressure is measured.

In addition to the physiological recordings and the psychological tests, the persons are at the end of each session asked to fill out a sheet of paper with questions of their subjective impressions during the exposure.

We have just finished the experiments in december 1978, and a lot of analyzing work is left, so I am not able to present any results yet.

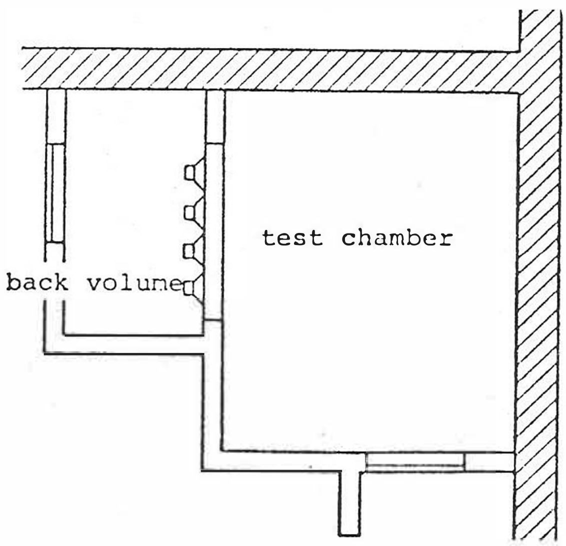

Figure 1. *The infrasound laboratory.*

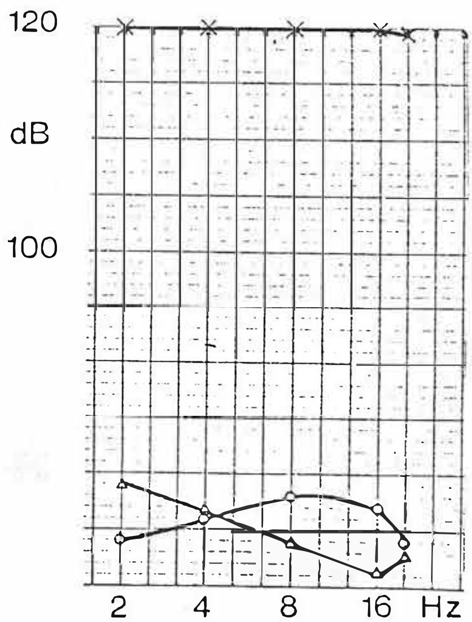

Figure 3. *Measurement of the harmonic distortion in the infrasound test chamber. (×) fundamental, (o) 2nd harmonic and(△) 3rd harmonic.*

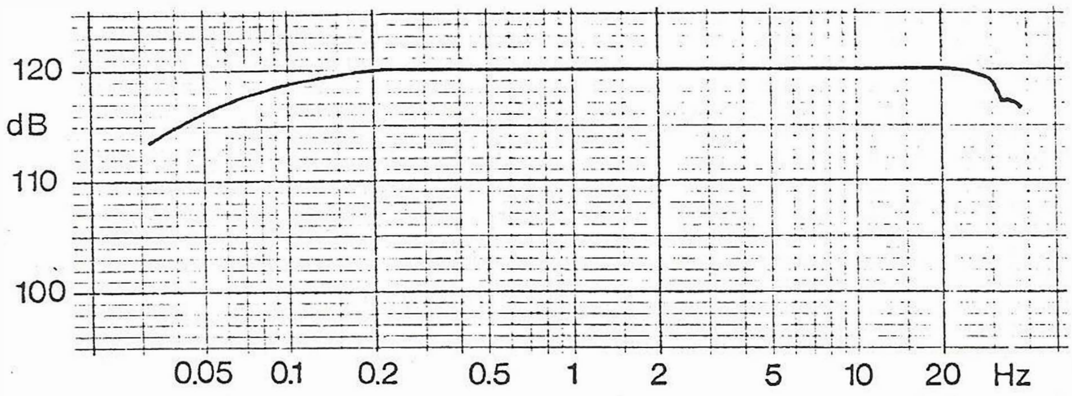

Figure 2. *Measurement of the sound pressure level in the test chamber with 1 V at the input of the frequency and gain correcting circuit.*

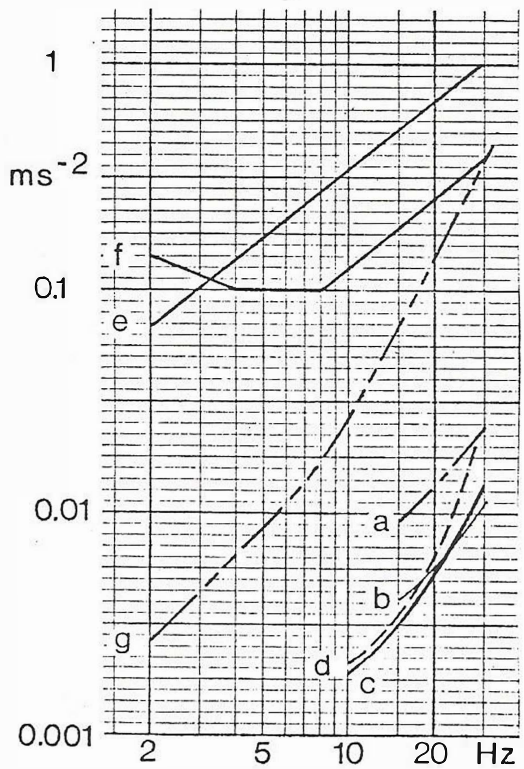

Figure 4. *Vibration measurements from surfaces of the test chamber with a fixed sound pressure level of 120 dB.*
Mounting of accelerometer:
a) ceiling, b) floor, c) wall, d) wall, g) door.
For reference the curves e) and f) are shown:
e) ISO 2631, "reduced comfort", 8 hour/day, vertical, f) same, horizontal.

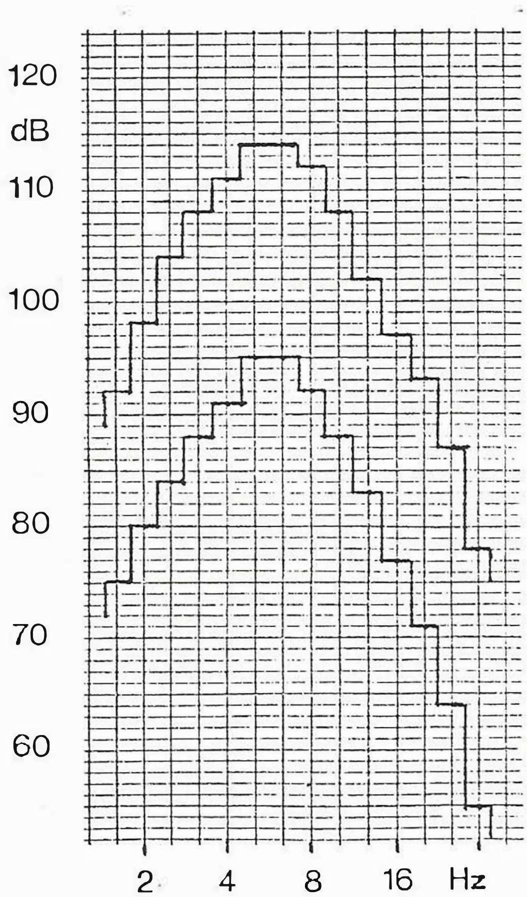

Figure 5. *A 1/3 octave analysis of the two infrasound noise spectra used in the experiments.*